Mechanisms of melt migration and mantle metasomatism in the lithosphere beneath the French Massif Central

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Introduction

The chemical and isotopic composition of the lithospheric mantle is greatly modified by the circulation of ascending melts, which migrate through hydraulic fractures or percolate along grain boundaries in a porous matrix. We investigated the compositional imprint of veinlet melts on the host peridotite, and analyzed the Sr-Nd isotopic compositions of amphiboles and clinopyroxenes.

Results and discussion

The nodules show textures varying from protogranular to equigranular. Olivine and pyroxenes are in equilibrium, and temperatures have been estimated at 900-1000°C. Kaersutite fills veinlets and forms selvage, and pargasite occurs as disseminated phases.The pargasite abundance is related to the intensity of the plastic deformation, and pargasite is rare in samples with a high degree of channelizing of the melt.

Compositional gradients are observed in amphiboles along the veins and away from the peridotite-hornblendite selvage contact, and in clinopyroxenes. Moreover, both phases have similar LREE-enriched patterns suggesting a link between modal metasomatism and trace element enrichment. The potential for metasomatic modification is greatly reduced at a cm-scale distance from the zone of initial melt supply, and appears to be related to the liquid / rock ratio. Amphiboles and clinopyroxenes have similar Sr and Nd isotopic ratios in all hydrous samples, distinct from those of anhydrous xenoliths, which further supports a single metasomatic episode, strong enough to completely rehomogeneize the isotopic composition.

In conclusion melt migration throughout fractures and infiltration from the fractures to their host represent the probable most effective process of mantle metasomatism. Such short-scale processes are likely to be responsible for metasomatism on a large scale due to the presence of numerous veins in the upper mantle. Depending on the depth at which the channelled flow extends before giving way to a dominant porous flow regim, this may greatly influences the production of mantle melts.

He, Ne, Ar-isotope composition of mantle xenoliths from Dreiser Weiher, West Eifel, Germany

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Knowledge of noble gas compositions in the Earth’s mantle has fundamental implications for the large-scale structure and dynamics of the mantle. While there are relatively abundant data from the suboceanic mantle, noble gas reservoirs beneath continents are less well characterised. The West Eifel (Germany) is an intra-continental volcanic region of particular interest, as a recent seismic study of the upper mantle below the Quaternary Eifel volcanic fields revealed the presence of a deep mantle plume beneath this area (Ritter et al., 2001).

At the Dreiser Weiher volcanic field abundant mantle xenoliths occur (e.g. Witt-Eickschen and Kramm (1988). We analysed argon extracted by stepwise heating from whole rock samples and mineral separates (Olv, Cpx, Opx, Amph) of clinopyroxenites, lherzolites, amphibole megacrysts, and also olivine phenocrysts. Highest $^{40}Ar/^{36}Ar$ ratios (up to 8000) were obtained for pyroxenes and amphiboles. Subsequent analyses of He, Ne and Ar (extracted by stepwise crushing) focussed on these samples. Clinopyroxene separates from two clinopyroxenites (DW906, DW918) yielded $^{40}Ar/^{36}Ar$ ratios up to 13400, and $^{20}Ne/^{22}Ne$ ratios up to 11.9. The high precision Ne data form mixing lines in a $^{20}Ne/^{22}Ne$ versus $^{21}Ne/^{22}Ne$ plot slightly steeper than the MORB line which could indicate a slight contribution of plume like neon. Our He-isotope data are consistent with relatively uniform $^{3}He/^{4}He$ ratios of about 6 R_a reported by Dunai and Baur (1995) for Eifel xenoliths. $^{4}He/^{40}Ar^*$ ratios are partly fractionated as observed previously for ultramafic xenoliths, but are close to theoretical production ratios in the case of DW906 ($^{4}He/^{40}Ar^*=2.0$).

References

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